EXAR

XR-2207

Voltage-Controlled Oscillator

GENERAL DESCRIPTION

The XR-2207 is a monolithic voltage-controlled oscillator (VCO) integrated circuit featuring excellent frequency stability and a wide tuning range. The circuit provides simultaneous triangle and squarewave outputs over a frequency range of 0.01 Hz to 1 MHz. It is ideally suited for FM, FSK, and sweep or tone generation, as well as for phase-locked loop applications.

The XR-2207 has a typical drift specification of 20 ppm/°C. The oscillator frequency can be linearly swept over a 1000:1 range with an external control voltage; and the duty cycle of both the triangle and the squarewave outputs can be varied from 0.1% to 99.9% to generate stable pulse and sawtooth waveforms.

FEATURES

Excellent Temperature Stability (20 ppm/°C)
Linear Frequency Sweep
Adjustable Duty Cycle (0.1% to 99.9%)
Two or Four Level FSK Capability
Wide Sweep Range (1000:1 Min)
Logic Compatible Input and Output Levels
Wide Supply Voltage Range (±4V to ±13V)
Low Supply Sensitivity (0.1%/V)
Wide Frequency Range (0.01 Hz to 1 MHz)
Simultaneous Triangle and Squarewave Outputs

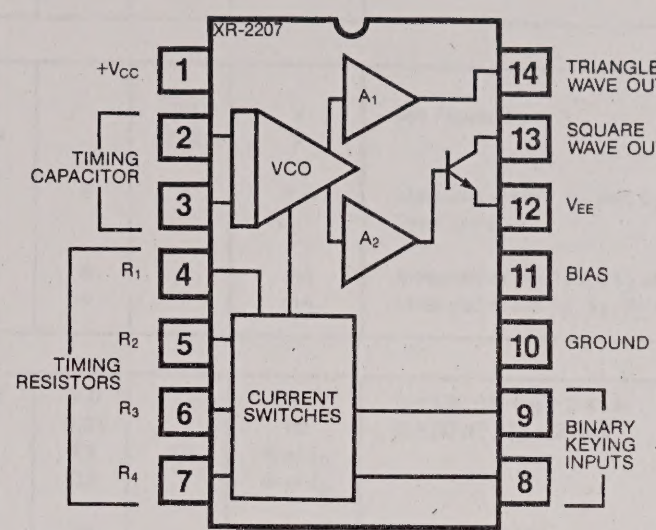
APPLICATIONS

FSK Generation
Voltage and Current-to-Frequency Conversion
Stable Phase-Locked Loop
Waveform Generation
  Triangle, Sawtooth, Pulse, Squarewave
FM and Sweep Generation

ABSOLUTE MAXIMUM RATINGS

Power Supply	26V
Power Dissipation (package limitation)	
Ceramic package	750 mW
Derate above +25°C	6.0 mW/°C
Plastic package	625 mW
Derate above +25°C	5 mW/°C
Storage Temperature Range	-65°C to +150°C

FUNCTIONAL BLOCK DIAGRAM



ORDERING INFORMATION

Part Number	Package	Operating Temperature
XR2207M	Ceramic	-55°C to +125°C
XR2207N	Ceramic	0°C to +75°C
XR2207P	Plastic	0°C to +75°C
XR2207CN	Ceramic	0°C to +75°C
XR2207CP	Plastic	0°C to +75°C

SYSTEM DESCRIPTION

The XR-2207 utilizes four main functional blocks for frequency generation. These are a voltage controlled oscillator (VCO), four current switches which are activated by binary keying inputs, and two buffer amplifiers for triangle and squarewave outputs. The VCO is actually a current controlled oscillator which gets its input from the current switches. As the output frequency is proportional to the input current, the VCO produces four discrete output frequencies. Two binary input pins determine which timing currents are channelled to the VCO. These currents are set by resistors to ground from each of the four timing terminals.

The triangle output buffer provides a low impedance output (10Ω TYP) while the squarewave is an open-collector type. A programmable reference point allows the XR-2207 to be used in either single or slip supply configurations.

ELECTRICAL CHARACTERISTICS

Test Conditions: Test Circuit of Figure 1, $V^+ = V^- = 6V$, $T_A = +25°C$, C = 5000 pF, $R_1 = R_2 = R_3 = R_4 = 20\ K\Omega$, $R_L = 4.7\ K\Omega$, Binary Inputs grounded, S_1 and S_2 closed unless otherwise specified.

PARAMETERS	XR-2207/XR-2207M			XR-2207C			UNITS	CONDITIONS
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.		
GENERAL CHARACTERISTICS								
Supply Voltage								
Single Supply	8		26	8		26	V	See Figure 3
Split Supplies	±4		±13	±4		±13	V	
Supply Current								
Single Supply		5	7		5	8	mA	Measured at pin 1, S_1 and S_2 open See Figure 2
Split Supplies								
Positive		5	7		5	8	mA	Measured at pin 1, S_1, S_2 open
Negative		4	6		4	7	mA	Measured at pin 12, S_1, S_2 open
OSCILLATOR SECTION – FREQUENCY CHARACTERISTICS								
Upper Frequency Limit	0.5	1.0		0.5	1.0		MHz	C = 500 pF, $R_3 = 2\ K\Omega$
Lowest Practical Frequency		0.01			0.01		Hz	C = 50 µF, $R_3 = 2\ M\Omega$
Frequency Accuracy		±1	±3		±1	±5	% of f_o	
Frequency Matching		0.5			0.5		% of f_o	
Frequency Stability								
Temperature		20	50		30		ppm/°C	$0° < T_A < 75°C$
Power Supply		0.15			0.15		%/V	
Sweep Range	1000:1	3000:1			1000:1		f_H/f_L	$R_3 = 1.5\ K\Omega$ for f_{H1} $R_3 = 2\ M\Omega$ for f_L
Sweep Linearity							%	C = 5000 pF
10:1 Sweep		1	2		1.5			$f_H = 10$ kHz, $f_L = 1$ kHz
1000:1 Sweep		5			5			$f_H = 100$ kHz, $f_L = 100$ Hz
FM Distortion		0.1			0.1		%	±10% FM Deviation
Recommended Range of Timing Resistors	1.5		2000	1.5		2000	KΩ	See Characteristic Curves
Impedance at Timing Pins		75			75		Ω	Measured at pins 4, 5, 6, or 7
DC Level at Timing Terminals		10			10		mV	
BINARY KEYING INPUTS								
Switching Threshold	1.4	2.2	2.8	1.4	2.2	2.8	V	Measured at pins 8 and 9, Referenced to pin 10
Input Impedance		5			5		KΩ	
OUTPUT CHARACTERISTICS								
Triangle Output								Measured at pin 13
Amplitude	4	6		4	6		V_{pp}	
Impedance		10			10		Ω	
DC Level		+100			+100		mV	Referenced to pin 10
Linearity		0.1			0.1		%	From 10% to 90% to swing
Squarewave Output								Measured at pin 13, S_2 closed
Amplitude	11	12		11	12		V_{pp}	
Saturation Voltage		0.2	0.4		0.2	0.4	V	Referenced to pin 12
Rise Time		200			200		nsec	$C_L \leq 10$ pF
Fall Time		20			20		nsec	$C_L \leq 10$ pF

PRINCIPLES OF OPERATION

TIMING CAPACITOR (PINS 2 AND 3)

The oscillator frequency is inversely proportional to the timing capacitor, C. The minimum capacitance value is limited by stray capacitances and the maximum value by physical size and leakage current considerations. Recommended values range from 100 pF to 100μF. The capacitor should be non-polar.

TIMING RESISTORS (PINS 4, 5, 6, AND 7)

The timing resistors determine the total timing current, I_T, available to charge the timing capacitor. Values for timing resistors can range from 1.5 KΩ to 2 MΩ; however, for optimum temperature and power supply stability, recommended values are 4 KΩ to 200 KΩ (see Figures 4, 7, and 8). To avoid parasitic pick up, timing resistor leads should be kept as short as possible. For noisy environments, unused or deactivated timing terminals should be bypassed to ground through 0.1 μF capacitors. Otherwise, they may be left open.

SUPPLY VOLTAGE (PINS 1 AND 12)

The XR-2207 is designed to operate over a power supply range of ±4V to ±13V for split supplies, or 8V to 26V for single supplies. At high supply voltages, the frequency sweep range is reduced (see Figures 3 and 4). Performance is optimum for ±6V, or 12V single supply operation.

BINARY KEYING INPUTS (PINS 8 AND 9)

The internal impedance at these pins is approximately 5 KΩ. Keying levels are <1.4V for "zero" and >3V for "one" logic levels referenced to the dc voltage at pin 10 (see Figure 9).

BIAS FOR SINGLE SUPPLY (PIN 11)

For single supply operation, pin 11 should be externally biased to a potential between $V^+/3$ and $V^+/2$ volts (see Figure 2). The bias current at pin 11 is nominally 5% of the total oscillation timing current, I_T.

GROUND (PIN 10)

For split supply operation, this pin serves as circuit ground. For single supply operation, pin 10 should be ac grounded through a 1μF bypass capacitor. During split supply operation, a ground current of $2I_T$ flows out of this terminal, where I_T is the total timing current.

SQUARE WAVE OUTPUT (PIN 13)

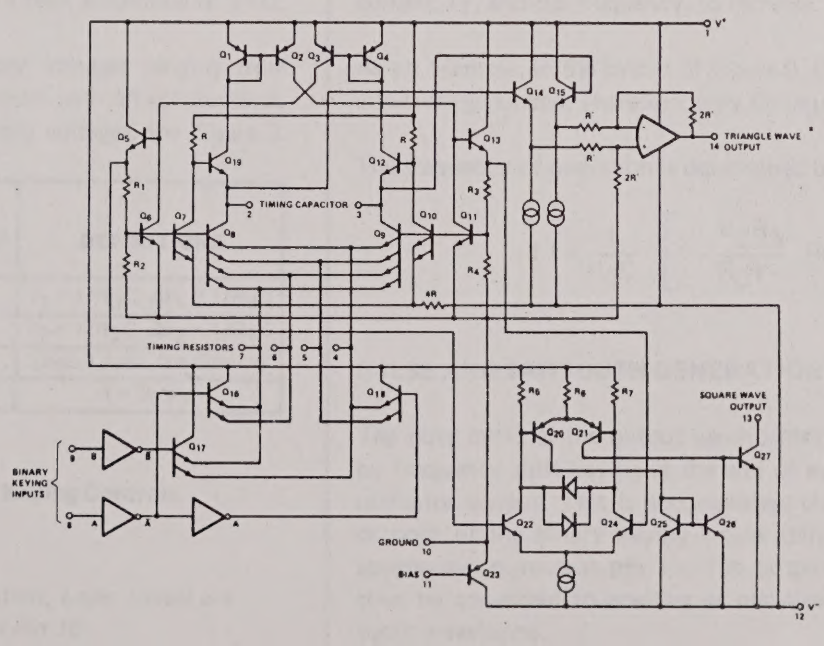
The squarewave output at pin 13 is a "open-collector" stage capable of sinking up to 20 mA of load current. R_L serves as a pull-up load resistor for this output. Recommended values for R_L range from 1 KΩ to 100 KΩ.

TRIANGLE OUTPUT (PIN 14)

The output at pin 14 is a triangle wave with a peak swing of approximately one-half of the total supply voltage. Pin 14 has a very low output impedance of 10Ω and is internally protected against short circuits.

Note: Triangle waveform linearity is sensitive to parasitic coupling between the square and the triangle-wave outputs (pins 13 and 14). In board layout or circuit wiring care should be taken to minimize stray wiring capacitances between these pins.

EQUIVALENT SCHEMATIC DIAGRAM



APPLICATIONS INFORMATION

PRECAUTIONS

The following precautions should be observed when operating the XR-2207 family of integrated circuits:

1. Pulling excessive current from the timing terminals will adversely effect the temperature stability of the circuit. To minimize this disturbance, it is recommended that the *total current* drawn from pins 4, 5, 6, and 7 be limited to ⩽6 mA. In addition, permanent damage to the device may occur if the total timing current exceeds 10 mA.
2. Terminals 2, 3, 4, 5, 6, and 7 have very low internal impedance and should, therefore, be protected from accidental shorting to ground or the supply voltages.
3. The keying logic pulse amplitude should not exceed the supply voltage.

SPLIT SUPPLY OPERATION

Figure 1 is the recommended circuit connection for split supply operation. The frequency of operation is determined by the timing capacitor, C, and the activated timing resistors (R_1 through R_4). The timing resistors are activated by the logic signals at the binary keying inputs (pins 8 and 9), as shown in the logic table (Table 1). If a single timing resistor is activated, the frequency is 1/RC. Otherwise, the frequency is either $1/(R_1||R_2)C$ or $1/(R_3||R_4)C$.

The squarewave output is obtained at pin 13 and has a peak-to-peak voltage swing equal to the supply voltages. This output is an "open-collector" type and requires an external pull-up load resistor (nominally 5 KΩ) to the positive supply. The triangle waveform obtained at pin 14 is centered about ground and has a peak amplitude of V+/2.

The circuit operates with supply voltages ranging from ±4V to ±13V. Minimum drift occurs with ±6 volt supplies. For operation with unequal supply voltages, see Figure 3.

LOGIC LEVEL 8	LOGIC LEVEL 9	SELECTED TIMING PINS	FREQUENCY	DEFINITIONS
0	0	6	f_1	$f_1 = 1/R_3C$, $\Delta f_1 = 1/R_4C$
0	1	6 and 7	$f_1 + \Delta f_1$	$f_2 = 1/R_2C$, $\Delta f_2 = 1/R_1C$
1	0	5	f_2	Logic Levels: 0 = Ground
1	1	4 and 5	$f_2 + \Delta f_2$	1 = >3 V

Table 1.
Logic Table for Binary Keying Controls

Note: For Single-Supply Operation, Logic Levels are Referenced to Voltage at Pin 10

SINGLE SUPPLY OPERATION

The circuit should be interconnected as shown in Figure 2 for single supply operation. Pin 12 should be grounded, and pin 11 biased from V^+ through a resistive divider to a value of bias voltage between $V^+/3$ and $V^+/2$. Pin 10 is bypassed to ground through a 1 μF capacitor.

For single supply operation, the dc voltage at pin 10 and the timing terminals (pins 4 through 7) are equal and approximately 0.6V above V_B, the bias voltage at pin 11. The logic levels at the binary keying terminals are referenced to the voltage at pin 10.

ON – OFF KEYING

The XR-2207 can be keyed on and off by simply activating an open circuited timing pin. Under certain conditions, the circuit may exhibit very low frequency (<1 Hz) residual oscillations in the "off" state due to internal bias currents. If this effect is undesirable, it can be eliminated by connecting a 10 MΩ resistor from pin 3 to V^+.

FREQUENCY CONTROL (SWEEP AND FM)

The frequency of operation is controlled by varying the total timing current, I_T, drawn from the activated timing pins 4, 5, 6, or 7. The timing current can be modulated by applying a control voltage, V_C, to the activated timing pin through a series resistor R_C as shown in Figure 9.

For split supply operation, a *negative* control voltage, V_C, applied to the circuits of Figure 9 causes the total timing current, I_T, and the frequency, to increase.

As an example, in the circuit of Figure 9, the binary keying inputs are grounded. Therefore, only timing pin 6 is activated.

The frequency of operation is determined by:

$$f = \frac{1}{R_3C}\left[1 - \frac{V_C R_3}{R_C V-}\right] \text{Hz}$$

PULSE AND SAWTOOTH GENERATION

The duty cycle of the output waveforms can be controlled by frequency shift keying at the end of every half cycle of oscillator output. This is accomplished by connecting one or both of the binary keying inputs (pins 8 or 9) to the squarewave output at pin 13. The output waveforms can then be converted to positive or negative pulses and sawtooth waveforms.

Figure 10 is the recommended circuit connection for duty cycle control. Pin 8 is shorted to pin 13 so that the circuit switches between the "0, 0" and the "1, 0" logic states given in Figure 9. Timing pin 5 is activated when the output is "high," and pin 6 is activated when the squarewave output goes to a low state.

The duty cycle of the output waveforms is given as:

$$\text{Duty Cycle} = \frac{1}{R_2 + R_3}$$

and can be varied from 0.1% to 99.9% by proper choice of timing resistors. The frequency of oscillation, f, is given as:

$$f = \frac{2}{C}\left[\frac{1}{R_2 + R_3}\right]$$

The frequency can be modulated or swept without changing the duty cycle by connecting R_2 and R_3 to a common control voltage V_C, instead of to V^-. The sawtooth and the pulse output waveforms are shown in Figure 5.

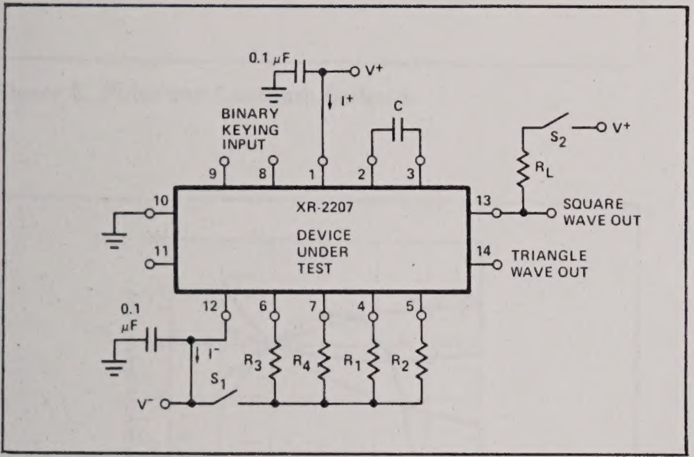


Figure 1. Test Circuit For Split Supply Operation

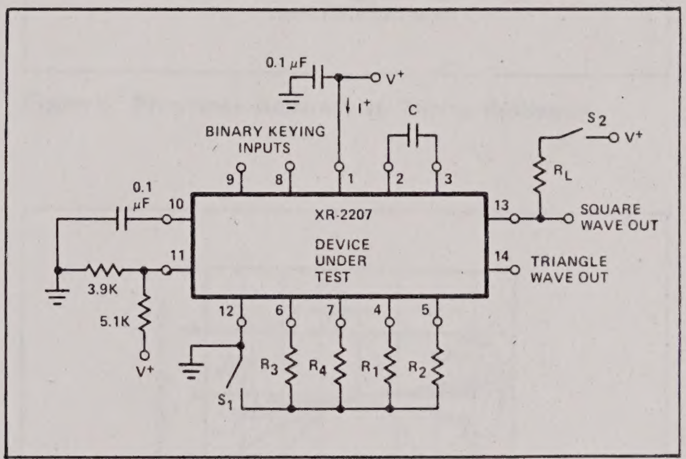


Figure 2. Test Circuit For Single Supply Operation

TYPICAL CHARACTERISTICS

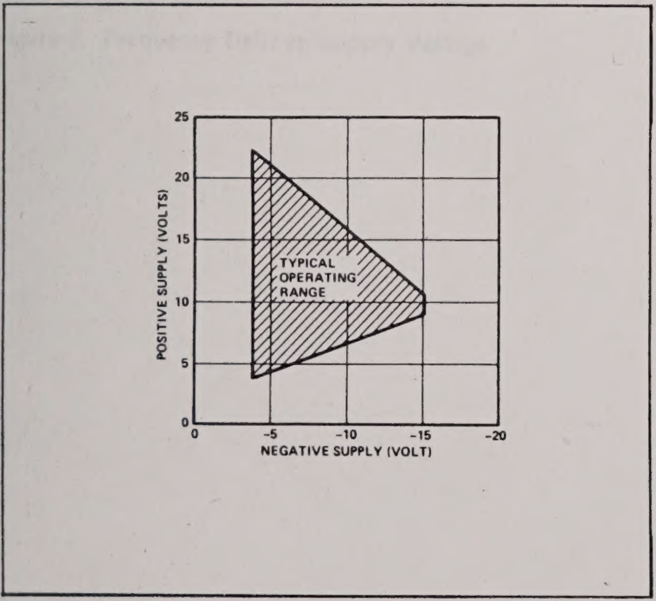


Figure 3. Typical Operating Range For Split Supply Voltage

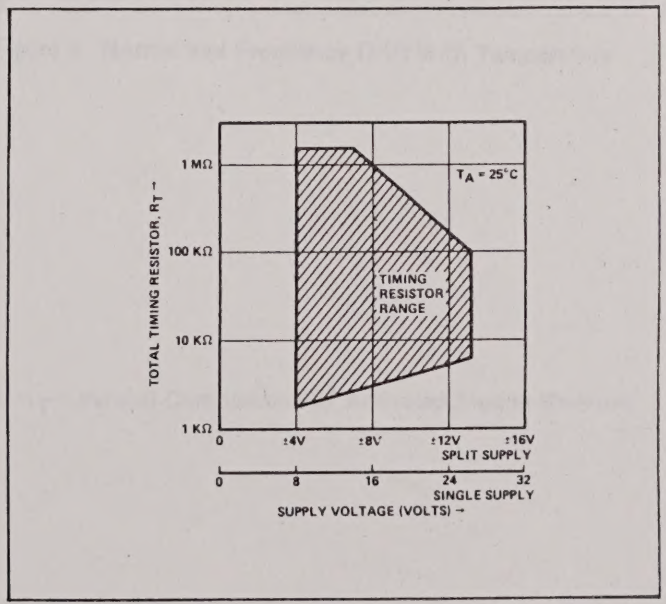


Figure 4. Recommended Timing Resistor Value vs. Power Supply Voltage*

TYPICAL CHARACTERISTICS Cont.

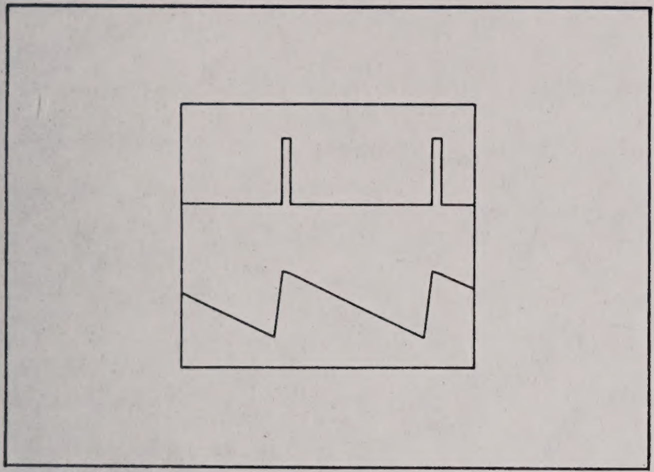


Figure 5. Pulse and Sawtooth Outputs

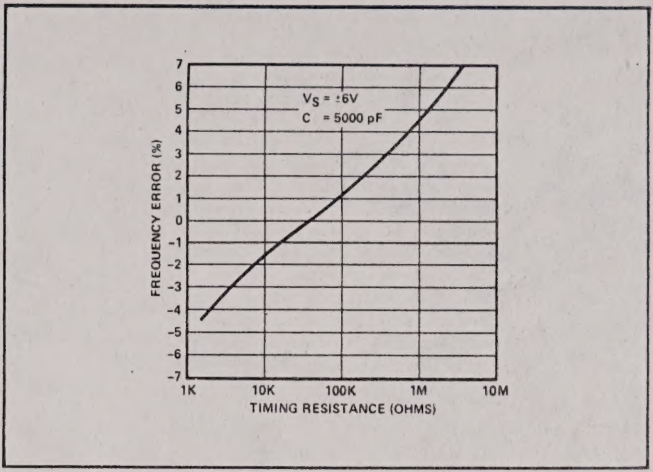


Figure 6. Frequency Accuracy vs. Timing Resistance

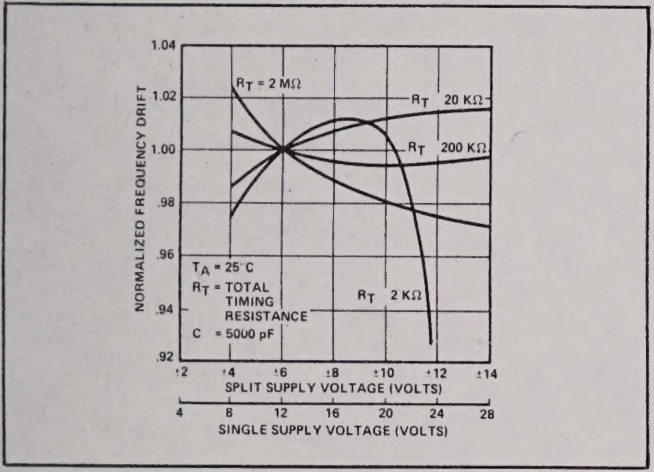


Figure 7. Frequency Drift vs. Supply Voltage

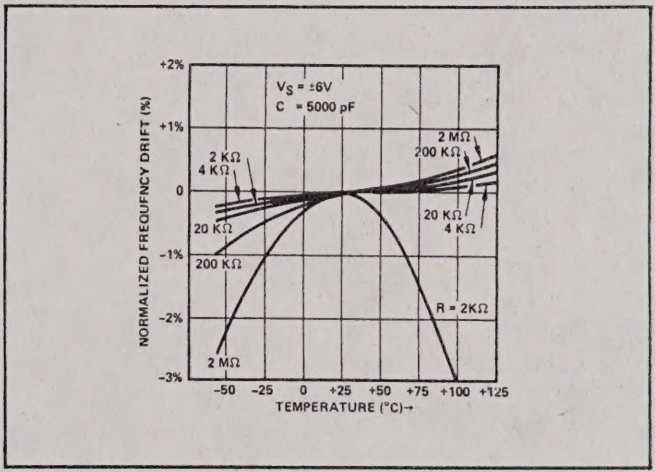


Figure 8. Normalized Frequency Drift With Temperature

*Note: R_T = Parallel Combination of Activated Timing Resistors